

bandwidth Airfone ACSB channel would be 8.5 dB stronger than the Airfone base station signal at the airplane. The relative transmit power is 100 W (Airfone base station) divided by 100 milliwatts (CT-2 base station) equals 1000 (30 dB). Thus the CT-2/Airfone Interference/Carrier ratio (I/C) is 8.5 minus 30 equals -21.5 dB. The ACSB system should have an I/C ratio of -8.0 dB or less to operate effectively. If an additional 10 dB of margin is required for fades in the Airfone channel, then the CT-2 service would still not cause noticeable interference into the Airfone channel during fading (-22.5 dB is less than the 18 dB threshold).

To improve the interference margins, frequency coordination can be used, that is, do not use the Airfone channel group frequencies in this city that an airplane would use in the vicinity of the city.

Airfone Base Station Interference into CT-2 Base Stations and User Terminals: The situation changes considerably in the reverse direction. AWC assumes two cases: 1) a 10-mile separation between CT-2 terminal and the Airfone base station; and 2) a more than 100-mile separation between the CT-2 base station/user terminals and the Airfone base station.

Case 1, 10-mile separation: The Airfone base station signal strength would be reduced about 25 dB over that predicted by the free-space path loss (Lee, 1986, p. 73) for an Airfone base antenna at 200 meters with a CT-2 user terminal at 3 m elevation. The relative free-space path loss of the Airfone base station and the CT-2 base station to the CT-2 user terminal located 10 miles and 0.3 mi., respectively, is $20\log(10/0.3)$ equals 30.5 dB. This is almost the same as the power ratio (100 W/100 mW equals 30 dB) which makes the signal received at the CT-2 user terminal from the Airfone base station roughly equal to the CT-2 base station signal. However, the Airfone may have several channels operating which would add up to 12 dB additional interference power in the 100 kHz bandwidth of the CT-2 base station receiver. Thus the predicted interference to carrier ratio (I/C) at the CT-2 user terminal or base station receiver is equal to relative transmit power (30 dB) plus relative path loss (-30.5 dB free-space plus -25 dB correction) plus multiple Airfone channels in the CT-2 receiver bandwidth (12 dB) equals -13.5 dB. Thus the interference is 13.5 dB less than the CT-2 signals. If an additional 20 dB of margin is required in the CT-2 network, operation of the CT-2 network will be impaired. Increased separation of CT-2 test location relative to the Airfone base station would improve the interference protection. Alternatively, avoiding operation on the Airfone channel group used by the Airfone base station would allow CT-2 operations.

Case 2, 100-mile separation: At 100 miles, the relative free-space loss is $20\log(100/0.3)$ equals 50.5 dB. The correction for terrestrial path loss is 60 dB (Lee, 1986, p. 73). Thus the predicted interference to carrier ratio (I/C) at the CT-2 receiver is equal to the relative transmit power (30 dB) plus relative path loss (-50.5 dB free-space plus -60 dB terrestrial path correction) plus multiple Airfone channels in the CT-2 receiver bandwidth (12 dB) equals -68.5 dB. This is well below the -12 dB threshold required for CT-2 operation. Hence, there is no interference of the Airfone base station into the CT-2 network.

Use of the 894-896 Airfone Frequencies (Downlink Band)

Interference of CT-2 into Airfone Base Station

Transceivers: Here AWC assumes that the worst scenario is for the airplane communicating with an Airfone base station channel in a city almost 200 miles away that contains an experimental CT-2 system. This is an example of a CT-2 implementation in the vicinity of San Francisco, California which is 10 to 30 miles from the closest next closest Airfone base station (Oakland, California) in this band. Thus the aircraft is at 200 miles range to the CT-2 system. The relative path losses between Airfone-equipped airplane and the CT-2 base/remote would be the ratio of $(200/10)^2$ in dB (26.0 dB). In addition, the CT-2 signal undergoes an additional 25 dB of loss because it has an (assumed 10-mile) terrestrial path to the Airfone base station. The relative bandwidth occupied by the CT-2 transmission compared with the Airfone channel is 100 kHz to 6 kHz or a factor of 16.7 (12 dB). Assuming uniform power density, the CT-2 interference power is reduced by 12 dB in the Airfone 6 kHz voice channel. The relative transmit power is 30 W (Airfone-equipped airplane transceiver) divided by 100 milliwatts (CT-2 Base Station) equals 300 (25 dB). Thus the CT-2/Airfone Interference/Carrier ratio (I/C) is the relative carrier powers (-25 dB) plus the relative path losses (26.0 dB free space plus -25 dB correction for the CT-2 terrestrial path) plus the CT-2 bandwidth spreading factor (-12 dB) equals -36.0 dB. The ACSB system (with pilot AGC control) should have an I/C ratio of -8.0 dB or less to operate effectively. If an additional 10 dB of margin is required for fades (I/C equals -18.0 dB or less) in the Airfone channel, then the CT-2 service will still not cause noticeable interference into the Airfone channel. If the CT-2 network is farther away (i.e., Case 2 above) there is even less interference into the Airfone base station.

Interference of Airfone into CT-2 Base Stations and User Terminals: Again, the situation changes in the reverse direction. Here the Airfone-equipped airplane is at 6 miles altitude over the CT-2 base station. The relative free-space path loss of the Airfone-equipped airplane transceiver and the CT-2 base station to the CT-2 user terminal located 6 miles and 0.3 mi., respectively, is $20\log(6/0.3)$ equals 26.0 dB. However, the Airfone transceiver may have several channels operating which would add up to 12 dB additional interference power in the 100 kHz bandwidth of the CT-2 base station receiver. Also, given the reduced CT-2 base station antenna gain at high elevation angles, another 10 dB of interference protection is obtained. Thus the predicted interference to carrier ratio (I/C) at the CT-2 base station receiver is equal to relative transmit power (25 dB) plus relative path loss (-26.0 dB free-space plus 10 dB correction for the short [0.3 mi.] terrestrial CT-2 user-to-base path) plus -10 dB for CT-2 base station antenna discrimination plus multiple Airfone channels in the CT-2 receiver bandwidth (12 dB) equals 11.0 dB almost 23 dB higher than the -12.0 dB CT-2 I/C threshold. The CT-2 user unit with an omni antenna with potentially less overhead discrimination would incur an I/C ratio of up to 21.0 dB. As a result, the CT-2 system would have to use a different Airfone channel group to avoid disruptive interference in this situation.

3.0 PROPOSED OPERATION

There are eight cases to consider defined by: 1) if the Airfone base station is in the same city as the CT-2 base station; 2) if the Airfone uplink (849-851 MHz) or downlink (894-896 MHz) band is being used for CT-2; and 3) if operation is limited by interference of Airfone into CT-2 or CT-2 into Airfone. The following table summarizes the interference analysis.

Airfone and CT-2 Base Stations
Co-Frequency Interference Analysis

	<u>Co-Located City</u> <u>(e.g., Oakland)</u>	<u>Separate Cities</u> <u>(e.g., Cincinnati)</u>
Airfone	AF to CT-2 = NOP	AF to CT-2 = NOP
Downlink Band		
894-896 MHz	CT-2 to AF = OK	CT-2 to AF = OK
Airfone	AF to CT-2 = ? to OK	AF to CT-2 = OK
Uplink Band		
849-851 MHz	CT-2 to AF = OK	CT-2 to AF = ? to OK

NOP: Not operable co-frequency (i.e., interference greatly exceeds thresholds).
? to OK: Small margins exist, experimental test data will be helpful.
OK: Wide Margins exist, should not be a problem.

The analysis shown in the Table indicates that in the downlink band, the Airfone interference into CT-2 prevents operation of the CT-2 network when an airplane operating co-frequency with CT-2 flies over the CT-2 network. Passive frequency coordination will prevent this occurrence. For instance, if the CT-2 network detected interference at its base or remote station on one of the channels expected to be co-frequency with Airfone-equipped aircraft in the vicinity, it would not use that channel on the CT-2 system. Interference from CT-2 network operations into Airfone base stations would be negligible so long as the CT-2 network were 10 miles or farther away from the Airfone base station. If not, frequency coordination would again resolve the conflict. In summary, in the downlink band the CT-2 network must use frequency coordination to operate without mutual interference between Airfone and CT-2.

In the uplink band, CT-2 does not interfere with Airfone operations in the same city by a wide margin, whereas Airfone may cause some interference into CT-2 operations. The opposite occurs when the base stations are in separate cities, 100 miles or farther apart. In this case, Airfone does not cause interference into CT-2, but CT-2 may cause marginal interference into overflying airplanes using Airfone. The simple expedient again is to use frequency coordination to avoid interference.

In the San Francisco area, CT-2 experiments will be conducted at distances more than 10 miles from the Airfone base station in Oakland. CT-2 operations will avoid the 850.8 to 851.0 MHz and 895.8 to 896.0 MHz Airfone channel groups.

In the Cincinnati area, CT-2 experiments should avoid the 894.6 to 894.8 and 894.8 to 985.0 MHz Airfone channel groups which are assigned to Airfone base stations in Ft. Wayne, Indiana, and Fairdale (Louisville), Kentucky, respectively. The corresponding 849.6 to 849.8 and 849.8 to 850.0 MHz channel group frequencies might successfully be used by the CT-2 network. Further data resulting from current experimentation will be provided as it becomes available to supplement the technical record in this proceeding.